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Three New Species of Frogs and a New Tadpole from Eastern Thailand

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Three New Species of Frogs and a New Tadpole from Eastern Thailand

Bryan L. Stuart,¹ Yodchaiy Chuaynkern,² Tanya Chan-ard,²
and Robert F. Inger¹

Abstract

We describe three new species of frogs from eastern Thailand based on old and new material. These represent a species of *Megophrys* from Chantaburi and Sa Kaeo Provinces, a species of *Odorrana* from Loei Province, and a species of *Fejervarya* from Ubon Ratchatani Province. Tadpoles are assigned to the new species of *Megophrys* and *Fejervarya* and to a recently described species of *Rhacophorus* from eastern Thailand using molecular identification.

Introduction

The frog fauna of eastern Thailand has received sporadic attention. Smith and Kloss (1915) were among the earliest workers and reported on a frog collection from coastal Chantaburi Province and neighboring offshore islands. Taylor's (1962) monograph on the amphibians of Thailand was based in part on frogs collected from Loei, Nong Khai, Ubon Ratchatani (as "Ubon"), and Chon Buri Provinces. Inger (1970) described *Paa fasciculispina*, and Wassersug et al. (1981) described the tadpole of *Theloderma stellatum* Taylor, 1962, both using material from Chantaburi Province. Fieldwork in Nakhon Ratchasima Province (primarily at Sakaerat Experimental Research Station) and adjacent Nakhon Nayok Province in 1969–1970 resulted in publications on frog calls (Heyer, 1971b), community ecology of tadpoles (Heyer, 1973, 1974) and adults (Inger & Colwell, 1977),

descriptions of tadpoles (Heyer, 1971a,c), and the description of *Odorrana indepressa* (Bain & Stuart, 2005). Most recently, Matsui and Panha (2006) described *Rhacophorus jarujini* from Kalasin and Roi Et Provinces.

In a review on the amphibians of Thailand, Chan-ard (2003) provided accounts and illustrations of three unnamed species from eastern Thailand, one each of *Megophrys* Kuhl and van Hasselt, 1822; *Odorrana* Fei et al. (1991 "1990"); and *Fejervarya* Bolckay, 1915. The new species of *Megophrys* was first collected more than two decades ago but has since remained unnamed. The new species of *Odorrana* was originally reported as *Rana livida* (Blyth, 1856) by Taylor (1962) and has since been hidden under that name in natural history collections. In 2004, we conducted fieldwork and obtained additional material of these three undescribed species as well as an unusually colored tadpole belonging to the genus *Rhacophorus* Kuhl and van Hasselt, 1822. Tadpoles are assigned to adults of the unnamed *Megophrys* and *Fejervarya* and to the recently described *Rhacophorus jarujini* Matsui and Panha, 2006, using molecular identification. Herein, we describe the new species of *Odorrana*, *Fejervarya*, and *Megophrys* and the tadpole of *R. jarujini*.

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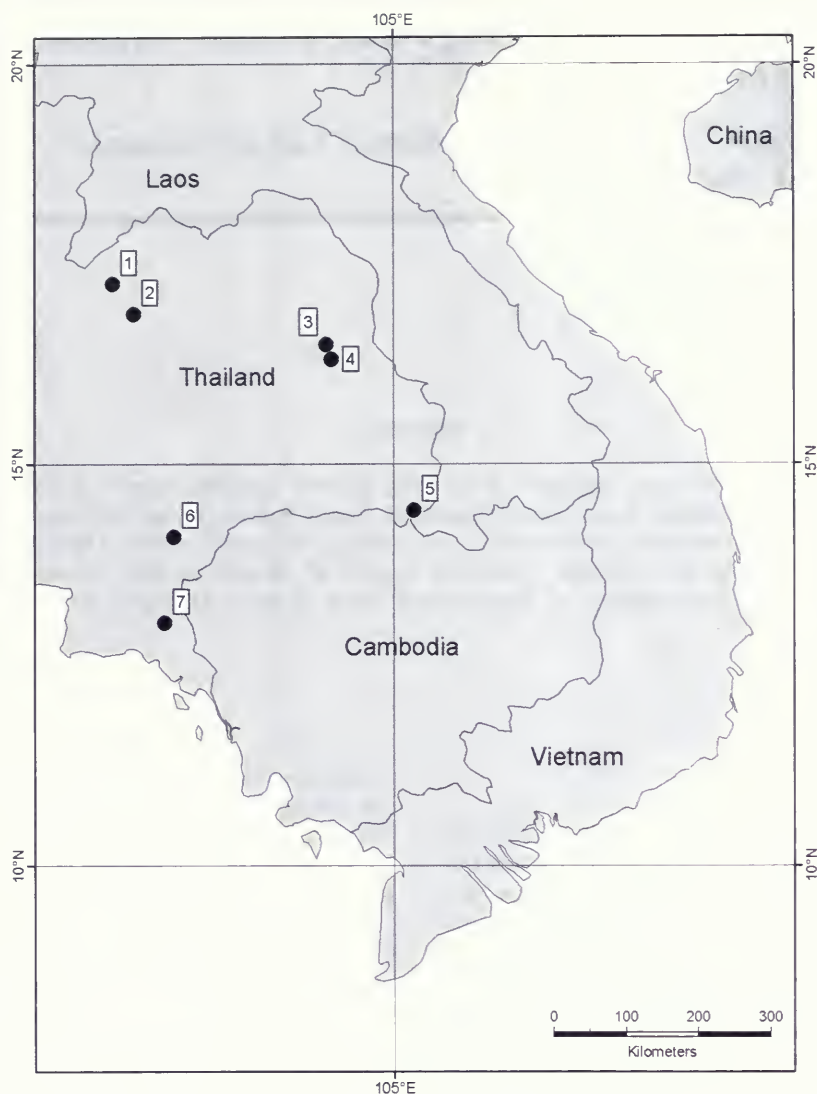


FIG. 1. Map of localities referred to in the text. 1 = Phu Luang Wildlife Sanctuary; 2 = Phu Kradueng National Park; 3 = Phu Sri Tan Wildlife Sanctuary; 4 = Phu Pha Namtip Non-hunting Area; 5 = Phu Jong-Na Yoi National Park; 6 = Pang Si Da National Park; 7 = Khao Soi Dao Wildlife Sanctuary. Fieldwork was conducted at localities 1, 5, and 6 in this study.

Materials and Methods

Fieldwork

In September 2004, two of us (YC, BLS) conducted fieldwork under the auspices of the Thailand Natural History Museum at Phu Luang Wildlife Sanctuary in Loei Province, Phu Jong-Na Yoi National Park in Ubon Ratchatani Province, and Pang Si Da National Park in Sa Kaeo Province, Thailand (Fig. 1).

These three protected areas are situated in the uplands at the northwestern, southeastern, and southwestern margins, respectively, of the Khorat Basin in eastern Thailand.

Phu Luang Wildlife Sanctuary was sampled at 850–1460 m elevation in hill evergreen, bamboo mixed with evergreen, and rhododendron heath forests. The last was encountered at 1460 m elevation on the summit of Kok Nok Kraba, where weather conditions were cool and foggy during our visit. Phu Jong-Na Yoi National Park

was sampled at 160–400 m elevation in deciduous dipterocarp forest with grassy understory (often with large areas of exposed igneous bedrock), hill evergreen forest, and disturbed evergreen forest. Pang Si Da National Park was sampled at 90–600 m elevation in hill evergreen forest, evergreen mixed with bamboo forest, disturbed evergreen forest, disturbed vegetation along abandoned roads, and around buildings.

Specimens were caught in the field by hand, preserved in 10% buffered formalin, and later transferred to 70% ethanol. Tissue samples were taken from frogs by preserving pieces of liver in 20% DMSO salt-saturated storage buffer before the specimen was fixed in formalin. Tissue samples were taken from tadpoles by preserving one or two representatives from a tadpole lot in 20% DMSO salt-saturated storage buffer.

Specimens are housed in the Field Museum of Natural History (FMNH) and the Thailand Natural History Museum (THNHM). Most specimens are cross-cataloged at both institutions, in which case voucher numbers are reported as FMNH/THNHM. The locations of holotypes are explicitly stated. The locations of paratypes and additional material can be obtained from the Field Museum of Natural History.

Morphology

Comparative material was examined in the holdings of FMNH, THNHM, California Academy of Sciences (CAS), Royal Ontario Museum (ROM), and University of California Museum of Vertebrate Zoology (MVZ). Data for *Megophrys jingdongensis* were taken from Fei et al. (1983), for *M. pachyproctus* from Huang et al. (1998), and for syntype males of *Odorrana graminea* from Boulenger (1920).

Measurements were made with dial calipers to the nearest 0.1 mm. Abbreviations used are SVL = snout-vent length; HDL = head length from tip of snout to rear of the jaws; HDW = maximum head width; SNT = snout length from tip of snout to the anterior corner of the eye; EYE = diameter of the exposed portion of the eyeball; IOD = narrowest point of interorbital distance; TMP = horizontal diameter of tympanum; TEY = tympanum-eye distance from anterior edge of tympanum to posterior corner of the eye; SHK = shank length; TGH = thigh length, from vent to outer edge of knee; HND = hand length, from base of palm to tip of Finger III; and FTL = foot length, from

proximal edge of inner metatarsal tubercle to tip of fourth toe.

DNA Extraction and Sequencing

Total genomic DNA was extracted from adults and tadpoles using PureGene Animal Tissue DNA Isolation Protocol (Gentra Systems, Inc.). A fragment of mitochondrial DNA that encodes part of the 16S ribosomal RNA gene (16S) was amplified from extractions of *Megophrys* and *Fejervarya* by the polymerase chain reaction (PCR; 94°C 45s, 60°C 30s, 72°C 1 min) for 35 cycles using the primers L-16SRanaIII (5'-GAGTTATTCAAATTAGGCACAGC-3') and H-16SRanaIII (5'-CATGGGGTCTTCTCGTCTTAT-3'). A fragment of mitochondrial DNA that encodes part of the cytochrome c oxidase subunit III gene, the complete tRNA glycine, the complete NADH dehydrogenase subunit 3 gene, and part of the tRNA arginine (ND3) was amplified from extractions of *Rhacophorus* by PCR (94°C 45s, 49°C 30s, 72°C 1 min) for 35 cycles using the primer pair L-COXIII (5'-CCGCATGATACTGACACTT-3') and Arg-HND3III (5'-AACTGTCTTTTTTGACTAGC-3'). PCR products were electrophoresed in a 1% low-melt agarose TALE gel stained with ethidium bromide and visualized under ultraviolet light. The bands containing DNA were excised, and agarose was digested from bands using GELase (Epicentre Technologies). PCR products were sequenced in both directions by direct double-strand cycle sequencing using Big Dye version 3 chemistry (Perkin Elmer) and the amplifying primers. Cycle sequencing products were precipitated with ethanol, 3 M sodium acetate, and 125 mM EDTA and sequenced with a 3730 DNA Analyzer (ABI). Sequences were edited and aligned with Sequencher version 4.1 (Genecodes) and deposited in GenBank (accession numbers DQ860092–DQ860097).

Species Accounts

Family Megophryidae

Genus *Megophrys* Kuhl and van Hasselt, 1822
Megophrys lekaguli sp. nov.

Megophrys sp. Chan-ard, 2003: 86.

HOLOTYPE—FMNH 213946 (field tag DLD 996.1), deposited at FMNH, adult female (Fig. 2),



FIG. 2. The adult female holotype (FMNH 213946) of *Megophrys lekaguli* sp. nov. in preservative. Clockwise from upper left: palmar view of hand; plantar view of foot; lateral view of head; dorsal view; ventral view.

collected in Khao Soi Dao Wildlife Sanctuary, Chantaburi Province, Thailand, 600–700 m elevation, on 26 September 1979 by Doyle Damman.

PARATYPES—FMNH 213947 (one adult male), FMNH 213948 (one adult female), same data as holotype. FMNH 191456 (one adult male), FMNH 191457 (one adult female), collected in Pong Nam Ron, Khao Soi Dao Tai Mountain, Chantaburi Province, Thailand, 1000 m elevation, on 28 November 1971, by Sukhum Pongsapipatana. THNHM 1101 (one adult male), THNHM 1034 (one adult female), collected in Khao Sabab Mountain, Namtok Phliu National Park, Khlung District, Chantaburi Province, Thailand, on 13 July–01 August, 2001, by Narongrit Sukprakarn. FMNH 265955/THNHM 05318, FMNH 265956/THNHM 05319, FMNH 265957/THNHM 05320 (three adult males), collected in Huay Kong Mou Now Stream, Pang Si

Da National Park, Muang Sa Kao District, Sa Kao Province, Thailand, 14°07'39.6"N 102°15'33.1"E, 600 m elevation, on 23–24 September 2004 by Yodchaiy Chuaynkern, Bryan L. Stuart, Chatchay Chuechat, and Sunchai Makchai. FMNH 265958/THNHM 05321, FMNH 265959/THNHM 05322 (two adult males), collected in Huay Km 29 Stream, Pang Si Da National Park, Muang Sa Kao District, Sa Kao Province, Thailand, 14°06'20.7"N 102°15'41.6"E, 600 m elevation, on 26–27 September 2004 by Yodchaiy Chuaynkern, Bryan L. Stuart, Chatchay Chuechat, and Sunchai Makchai (Fig. 3).

OTHER MATERIAL—FMNH 266341/THNHM 05391, tadpoles (Figs. 4–5), collected in Huay Km 29 Stream, Pang Si Da National Park, Muang Sa Kao District, Sa Kao Province, Thailand, 14°06'20.7"N 102°15'41.6"E, 600 m elevation, on 21 September 2004 by Yodchaiy Chuaynkern,



FIG. 3. An adult male paratype of *Megophrys lekaguli* sp. nov. in life.

Bryan L. Stuart, Chatchay Chuechat, and Sunchai Makchai. FMNH 266342/TNHM 05397 (tadpoles), collected in Huay Kong Mou Now Stream, Pang Si Da National Park, Muang Sa Kao District, Sa Kao Province, Thailand, 14°07'39.6"N 102°15'33.1"E, 600 m elevation, on 23 September 2004 by Yodchaiy Chuaynkern, Bryan L. Stuart, Chatchay Chuechat, and Sunchai Makchai.

DIAGNOSIS—A medium-sized species of *Megophrys* having males with SVL 36.6–66.6, females with SVL 71.8–94.0; strongly projecting snout; no dermal projection on rostrum; weakly visible palpebral tubercle; vomerine teeth on two short ridges transverse to the body axis; wide, dark vertical bar below eye; no light-colored upper lip stripe; narrow, external, vertical face of upper eyelid dark brown with a light area in its center; distinct tympanum more than half of eye diameter; relative finger lengths $IV < II < I < III$; toes webbed only at base and lacking dermal fringes.

DESCRIPTION OF HOLOTYPE—Habitus moderately stocky; head slightly wider than long, not wider than trunk; snout obtusely pointed in dorsal view, strongly projecting beyond lower

jaw, oblique in profile; nostril lateral, with a low ridge of skin around dorsal and posterior margins, midway between eye and tip of snout; canthus distinct; lores concave and acute; eye diameter 88% snout length; interorbital distance much greater than width of upper eyelid; pineal body absent; tympanum visible, 61% the eye diameter, not depressed relative to skin of temporal region; vomerine teeth on two small ridges transverse to body axis, closer to choanae than to each other; tongue unnotched.

Tips of fingers round; relative finger lengths $IV < II < I < III$; fingers without dermal fringes; fingers without subarticular tubercles, supernumerary tubercles, and palmar tubercles.

Tips of toes round; Toe III longer than Toe V; toes with rudiment of web, Toe IV with four phalanges free of webbing, no fringe extending along margins of Toe IV; toes with ventral callous ridges, but no subarticular tubercles; a low, callous inner metatarsal tubercle, subequal to length of Toe I; no outer metatarsal tubercle. Hind limb moderate in length, heels overlapping when leg flexed at right angles to the body; shank 49% snout-vent length.

Skin smooth on all surfaces; top of head and back with many whitish asperities; no dermal projection on rostrum; weakly visible palpebral tubercle; strong supratympanic fold from eye to above shoulder; weak dermal ridge with whitish asperities from eyes meeting to form a V over shoulder region, continuing as a vertebral line, and forming an inverted V over sacrum; weak dermal ridge with whitish asperities extending from near supratympanic fold to rear of body; scattered, low, round, whitish tubercles on temporal region, dorsal surface of forelimb, flank, dorsal surface of tibiotarsus, and posterior and ventral surfaces of thigh; round, whitish pectoral gland near axilla; round, whitish femoral gland, larger than pectoral gland, on posterior surface of thigh, closer to knee than vent.

Measurements (mm) of holotype: SVL 71.8; HDL 24.3; HDW 26.9; SNT 8.5; EYE 7.5; IOD

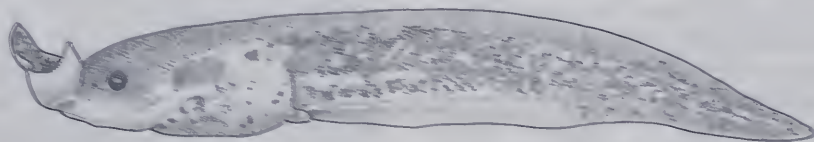


FIG. 4. Lateral view of tadpole (FMNH 266341/TNHM 05391) of *Megophrys lekaguli* sp. nov. Scale bar = 5 mm.

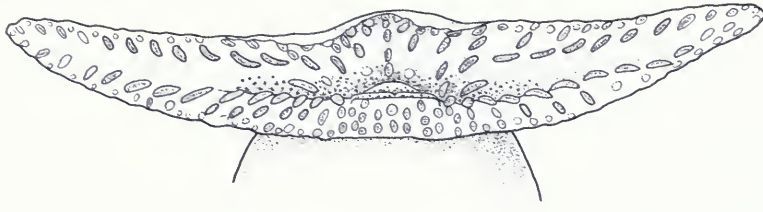


FIG. 5. Mouthparts of tadpole (FMNH 266341/THNHM 05391) of *Megophrys lekaguli* sp. nov. Scale bar = 1 mm.

8.2; TMP 4.6; TEY 5.4; SHK 35.5; TGH 35.3; HND 19.5; FTL 32.6.

COLOR OF HOLOTYPE IN PRESERVATIVE—Dorsum brown to grayish brown; dark brown band between eyes; narrow, external, vertical face of upper eyelid dark brown with a light area in its center; dark hourglass-shaped marking on back; side of head light brown, with a wide, vertical, dark bar below eye, a narrow dark bar at lip anterior to eye, and a narrow dark bar at lip posterior to eye, all separated by light areas on the margin of the upper lip; tympanum and adjacent area dark brown; laterally body light brown with dark spots ventrolaterally; throat and chest brown with irregular darker markings, becoming lighter posteriorly, creamy-white near groin; limbs with narrow dark brown crossbars; lower half of posterior surface of thigh brown, with a dark brown area beginning at vent and extending distally; ventral surface of thigh and ventral surface of shank dusky brown; posterior surface of shank with three large black spots; ventral surface of tarsus and foot uniform purplish brown.

COLOR OF PARATYPE MALE FMNH 265955 IN LIFE—Dorsum light grayish brown with dark brown markings; upper eyelid, supratympanic fold, and flank with yellowish wash; upper lip, inguinal region, anterior and posterior surface of thigh, and posterior surface of shank with salmon wash; dorsal surface of fingers and toes orange with black spots; ventral surface of hand and foot purplish gray; throat and chest dark gray with salmon wash; posterior part of belly pinkish white; pectoral and femoral glands creamy-white; forelimb, knee, posterior surface of shank, and dorsal surface of tarsus with black spots; eye orange with black reticulations and black, vertical pupil.

MOLECULAR RESULTS—A tadpole (FMNH 266341/THNHM 05391) and an adult male paratype (FMNH 265959/THNHM 05322) are identical in a 704 bp fragment of 16S.

DESCRIPTION OF TADPOLE—Body slender, oval, flattened above; tail about as deep as body, dorsal fin arising behind origin of tail, maximum depth near mid-length, tapering gradually to narrow, rounded tip; tail 2.1–2.2 times body length, tail depth 20–23% of tail length. Maximum body width 50–54% of body length, body depth 40–42% of body length. Eyes dorsolateral, pointing laterally. Nares open, dorsolateral, slightly closer to eyes than to oral funnel, rim not raised; internarial wider than interorbital. Spiracle closer to eye than to end of body, midway up side, tube not free of body wall. Anal tube ending at margin of ventral fin, opening medial.

Oral disk terminal, lips expanded and directed upwardly into typical *Megophrys* funnel; transverse width of expanded funnel 75% of body length.

Color in preservative of body light gray above, sides and venter with small black spots; proximal half of caudal muscle with two or three irregular dark streaks, distal half dusky, mid-dorsal edge of muscle light; fins distinctly pigmented only in distal portions.

Body lengths (stage = mm): 25 = 9.0, 10.4; 37 = 12.1, 12.9; 38 = 13.8; 42 = 14.2.

VARIATION—Measurements of paratypes summarized in Table 1. Chantaburi males (SVL 63.6–66.6, mean \pm S.D. 64.9 ± 1.5 , $N = 3$) are larger than Sa Kaeo males (SVL 56.6–58.8, mean \pm S.D. 57.8 ± 0.9 , $N = 5$). Males with dark brown nuptial pad covering most of the dorsal surface of Finger I and a smaller, round area on the dorsal surface of Finger II. Four males have small, dark asperities on the upper and lower lip, concentrated anteriorly. Ova in preservative approximately 2 mm diameter, uniformly light yellow, without pigmented hemisphere. Dorsum in preservative light brown to dark gray. In preservative, the dark hourglass-shaped marking on the back and the dark band between the eyes is more conspicuous in some paratypes than in the holotype. The dark brown band is an

TABLE 1. Measurements (mm) of *Megophrys lekaguli* sp. nov. Abbreviations defined in the text.

Measurement	Adult males (paratypes)	Adult females (holotype and paratypes)
	Range; mean \pm S.D. (N = 8)	Range; mean \pm S.D. (N = 4)
SVL	56.6–66.6; 60.7 \pm 4.1	71.8–94.0; 80.5 \pm 9.8
HDL	21.0–23.1; 22.2 \pm 0.7	24.3–30.4; 27.4 \pm 2.5
HDW	22.1–24.3; 23.3 \pm 0.8	26.9–33.1; 29.9 \pm 2.5
SNT	7.5–8.4; 8.0 \pm 0.3	8.5–9.5; 9.1 \pm 0.4
EYE	6.5–7.5; 6.9 \pm 0.3	7.5–9.3; 8.7 \pm 0.8
IOD	6.2–7.5; 7.0 \pm 0.5	8.2–9.9; 9.2 \pm 0.7
TMP	4.1–4.9; 4.5 \pm 0.3	4.6–5.9; 5.3 \pm 0.6
TEY	3.5–4.2; 3.8 \pm 0.2	5.2–6.7; 5.9 \pm 0.7
SHK	26.8–33.4; 29.9 \pm 2.7	35.5–41.8; 39.1 \pm 3.1
TGH	28.2–33.8; 30.8 \pm 2.0	35.3–42.0; 39.3 \pm 3.0
HND	14.5–17.5; 16.1 \pm 1.2	19.5–22.0; 20.4 \pm 1.1
FTL	24.1–29.3; 26.7 \pm 1.9	32.6–37.4; 34.9 \pm 2.1
	Range; median (N = 8)	Range; median (N = 4)
HDL:HDW	0.90–1.00; 0.96	0.90–0.93; 0.92
SNT:HDL	0.35–0.39; 0.35	0.30–0.35; 0.34
TMP:EYE	0.59–0.74; 0.62	0.58–0.64; 0.61
EYE:SNT	0.77–0.94; 0.87	0.88–1.02; 0.96
SHK:SVL	0.47–0.52; 0.49	0.44–0.52; 0.50

inverted triangle in all paratypes. Sa Kao males in life had the dorsum grayish brown, yellowish tan, or orange-tan; dorsal surface of forelimb sometimes with yellowish wash; upper lip, flank, inguinal region, anterior and posterior surface of thigh, anterior and posterior surface of shank, throat and chest with salmon or orange wash; and the posterior part of belly pinkish white or light gray with dark mottling.

COMPARISONS—Twelve other species of *Megophrys* are known to occur within the vicinity of eastern Thailand (Thailand, Myanmar, Cambodia, Laos, and Vietnam): *M. aceras* (Boulenger, 1903), *M. auralensis* Ohler, Swan and Daltry, 2002, *M. brachykolos* Inger and Romer, 1961, *M. jingdongensis* Fei and Ye in Fei, Ye and Huang, 1983, *M. kuatunensis* (Pope, 1929), *M. longipes* (Boulenger, 1885), *M. major* (Boulenger, 1908), *M. minor* Stejneger, 1926, *M. nasuta* (Schlegel, 1858), *M. pachyproctus* Huang in Huang and Fei, 1981, *M. palpebralespinosa* Bourret, 1937, and *M. parva* (Boulenger, 1893). *Megophrys lekaguli* differs from *M. brachykolos*, *M. kuatunensis*, *M. minor*, *M. pachyproctus*, *M. palpebralespinosa*, and *M. parva* by having much larger body size (males with SVL 56.6–66.6 and females with SVL 71.8–94.0 in *lekaguli*; males < 48, females < 55 in *brachykolos*, *kuatunensis*, *minor*, *pachyproctus*, *palpebralespinosa*, and *parva*). *Megophrys lekaguli* differs from *M. aceras*, *M. longipes*, and *M. nasuta* by lacking a distinct palpebral projection (present in *aceras*, *longipes*,

and *nasuta*). *Megophrys lekaguli* differs from *M. jingdongensis* by having toes with only a rudiment of webbing (toe webbing well developed in *jingdongensis*) and lacking subarticular tubercles on Fingers I and II (present in *jingdongensis*). *Megophrys lekaguli* most closely resembles *M. auralensis* and *M. major*. *Megophrys lekaguli* differs from *M. auralensis* by having teeth on vomerine ridges (no teeth on vomerine ridges in *auralensis*), having males with SVL 56.6–66.6 (males with SVL 71.0–76.9 in *auralensis*), lacking dermal fringes on toes (present in *auralensis*), and having Finger II longer than Finger IV (Finger II shorter than Finger IV in *auralensis*). *Megophrys lekaguli* differs from *M. major* by lacking dermal fringes on toes (present in *major*); lacking a light-colored upper lip stripe (present in *major*); having the narrow, external, vertical face of the upper eyelid dark brown with a light area in its center (uniformly dark brown in *major*); and having a single row of weakly visible asperities on the underside of the lower jaw (well-developed broad band of asperities in *major*).

ETYMOLOGY—The specific epithet is a patronym for Dr. Boonsong Lekagul (1907–1992), biologist and conservationist, in recognition of his contributions to the herpetology of Thailand.

DISTRIBUTION AND ECOLOGY—*Megophrys lekaguli* is currently known from Chanthaburi and Sa Kao Provinces, Thailand (Fig. 1). Frogs were collected in Sa Kao at night (1815–2126 h) on

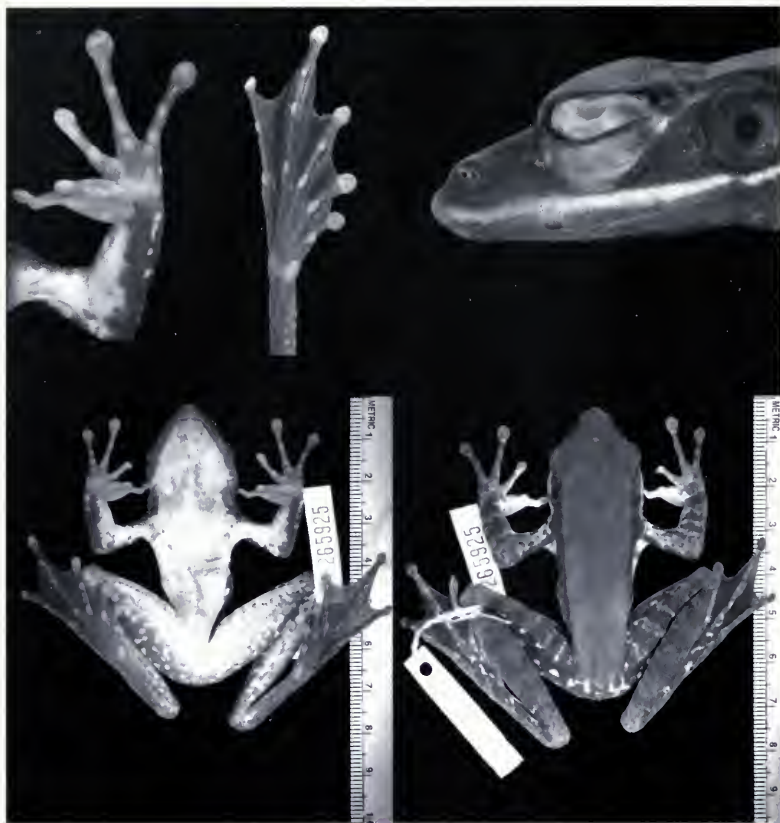


FIG. 6. The adult male holotype (FMNH 265925/THNHM 05341) of *Odorrana aureola* sp. nov. in preservative. Clockwise from upper left: palmar view of hand; plantar view of foot; lateral view of head; dorsal view; ventral view.

boulders and rock outcrops above a swift, rocky stream with waterfalls in hilly evergreen mixed with bamboo forest and on leaf litter next to a large tree root network 20 m from a swift, rocky stream in disturbed vegetation next to an abandoned road through hilly evergreen forest. Tadpoles were collected at night (2000–2015 h) swimming at the water surface in a 3-m-wide swift, rocky stream in hilly evergreen mixed with bamboo forest and in a shallow stream pool with silt substrate in disturbed vegetation next to an abandoned road through hilly evergreen forest. All five of the Sa Kaoe adult males were calling.

REMARKS—The two species that most closely resemble the new species, *M. auralensis* and *M. major*, were placed in the genus *Xenophrys* Günther, 1864 by Khonsue and Thirakhupt (2001; *M. major* as *M. lateralis*) and Frost (2004) without supporting argument. Frost et al. (2006) argued for recognition of *Xenophrys* because their phylogenetic analysis recovered

Megophrys as more closely related to *Ophryophryne* than to *Xenophrys*. However, their analysis was based only on a single species of *Megophrys* and *Xenophrys*, and we feel that this issue remains unresolved. We therefore leave the new species in the genus *Megophrys*, pending a phylogenetic analysis with improved taxonomic sampling.

Family Ranidae

Genus *Odorrana* Fei et al. (1991 “1990”)

Odorrana aureola sp. nov.

Rana livida (part) Taylor, 1962: 468; Inger and Chan-ard, 1997: 65.

Rana sp. Chan-ard, 2003: 138.

Odorrana cf. *livida* Stuart, Inger and Voris, 2006: fig. 2.

HOLOTYPE—FMNH 265925/THNHM 05341 (field tag HKV 66220), deposited at THNHM, adult male (Fig. 6), collected on a large boulder on the bank



FIG. 7. An adult female paratype (FMNH 265919/THNHM 05346) of *Odorrana aureola* sp. nov. in life.

of Sung Mak Hing Stream above Tad Loei Waterfall in hilly evergreen forest in Phu Luang Wildlife Sanctuary, Phu Rua District, Loei Province, Thailand, 17°15'32.4"N 101°30'22.8"E, 1100–1300 m elevation, on 03 September 2004 by Yodchaiy Chuaynkern, Bryan L. Stuart, Chatchay Chuechat, and Sunchai Makchai.

PARATYPES—FMNH 265924/THNHM 05351, FMNH 265926/THNHM 05352 (two females), FMNH 265923/THNHM 05350, FMNH 265927/THNHM 05353 (two immature females), same data as holotype. FMNH 265919/THNHM 05346 (Fig. 7), FMNH 265920/THNHM 05347, FMNH 265921/THNHM 05348, FMNH 265922/THNHM 05349 (four females), collected at Kok Nok Kraba, Phu Luang Wildlife Sanctuary, Phu Rua District, Loei Province, Thailand, 17°16'48.7"N 101°31'07.5"E, 1460 m elevation, by Yodchaiy Chuaynkern, Bryan L. Stuart, Chatchay Chuechat, and Sunchai Makchai. FMNH 264541, THNHM 05721 (two males), FMNH 264542, THNHM 05720 (two females), collected near Lon Moei in Phu Luang Wildlife Sanctuary, Phu Rua District, Loei Province, Thailand, 1400–1500 m elevation, in September–October 1998 by Tanya Chan-ard. FMNH 172378–80 (three males), collected at Phu Kading (=Phu Kradueng National Park), Loei Province, Thailand on 14 March 1958 by Edward H. Taylor.

DIAGNOSIS—A species of *Odorrana* having all digit tips expanded with circummarginal grooves; first finger longer than second; smooth skin; males with SVL 63.6–67.4, females with SVL 87.1–96.5; males sometimes with white spinules on temporal region, tympanic rim, rictal gland, upper and lower lip near gape, and postaxial side

of Toe V; posterior surface of forearm, ventral half of flank, anterior surface of thigh, posterior surface of thigh, posterior surface of shank, and dorsal surface of foot black with distinct, vermiform, bright yellow (creamy-white in preservative) markings; upper lip stripe yellow (creamy-white in preservative); males with gular pouches; and unpigmented eggs.

DESCRIPTION OF HOLOTYPE—Habitus moderately slender; head narrow, longer than wide; snout obtusely pointed in dorsal view, projecting beyond lower jaw, round in profile, slightly depressed; nostril lateral, slightly closer to tip of snout than eye; canthus distinct, slightly constricted behind nostrils; lores concave and oblique; eye diameter 81% snout length; interorbital distance less than width of upper eyelid; pineal body visible; distinct, round tympanum, 64% the eye diameter, not depressed relative to skin of temporal region, tympanic rim elevated relative to tympanum; vomerine teeth on two slightly oblique ridges, closer to each other than to choanae; tongue notched; vocal sac opening at corner of mouth; sac-like gular pouch at corner of throat.

Tips of all four fingers expanded with circummarginal grooves; width of Finger III disc about 2 times the width of phalanx, 42% the diameter of tympanum; relative finger lengths $II < I < IV < III$; ventral callous pad on Fingers II, III, and IV from distal edge of proximal subarticular tubercle to base of disc; movable flap of skin on preaxial side of Fingers II and III; one subarticular tubercle on Fingers I and II, two subarticular tubercles on Fingers III and IV; one supernumerary tubercle proximal to proximal subarticular tubercle on Fingers II, III, and IV; two palmar tubercles at base of III and IV, large, oval, in contact; velvety nuptial pad on Finger I, covering the dorsal surface to the level of the distal edge of the subarticular tubercle, covering the medial surface to base of finger disc; forearm robust.

Tips of toes expanded, width of Toe IV disc slightly less than width of Finger III disc; Toe III shorter than Toe V; all toes fully webbed to base of discs, notch in webbing between Toes IV and V extends to second subarticular tubercle on Toe IV; movable flap of skin on preaxial side of Toe I from subarticular tubercle to base of disc, on postaxial side of Toe V from slightly proximal of proximal subarticular tubercle to base of disc; elongate, oval inner metatarsal tubercle; no outer metatarsal tubercle.

TABLE 2. Measurements (mm) of *Odorrana aureola* sp. nov. Abbreviations defined in the text.

Measurement	Adult males (holotype and paratypes)	Adult females (paratypes)
	Range; mean \pm S.D. (N = 6)	Range; mean \pm S.D. (N = 7)
SVL	63.6–67.4; 65.3 \pm 1.6	87.1–96.5; 92.4 \pm 3.1
HDL	22.9–25.5; 24.3 \pm 1.1	31.7–33.8; 32.6 \pm 0.8
HDW	21.0–22.9; 22.1 \pm 0.8	29.3–31.8; 30.8 \pm 1.0
SNT	10.2–11.3; 10.6 \pm 0.4	14.0–16.1; 15.2 \pm 0.7
EYE	7.9–9.0; 8.4 \pm 0.4	10.0–11.4; 10.3 \pm 0.5
IOD	4.1–5.0; 4.8 \pm 0.4	7.5–9.5; 8.6 \pm 0.6
TMP	5.3–5.5; 5.4 \pm 0.1	5.8–6.7; 6.2 \pm 0.3
TEY	1.6–2.0; 1.9 \pm 0.2	2.2–3.4; 3.0 \pm 0.4
SHK	40.0–43.7; 41.3 \pm 1.4	55.5–61.6; 59.5 \pm 2.4
TGH	35.0–40.0; 37.6 \pm 2.0	50.7–56.0; 53.7 \pm 2.2
HND	17.4–18.7; 18.4 \pm 0.5	22.6–27.0; 25.8 \pm 1.6
FTL	33.9–36.5; 35.5 \pm 1.0	47.0–53.6; 51.4 \pm 2.5
	Range; median (N = 6)	Range; median (N = 7)
HDL:HDW	1.04–1.21; 1.08	1.02–1.09; 1.07
SNT:HDL	0.42–0.46; 0.44	0.43–0.48; 0.47
TMP:EYE	0.61–0.70; 0.65	0.57–0.63; 0.60
EYE:SNT	0.75–0.87; 0.77	0.62–0.75; 0.66
SHK:SVL	0.61–0.66; 0.63	0.60–0.67; 0.65

Skin smooth on all surfaces except granular on venteroposterior surface of thigh; few small tubercles in temporal and tympanic regions; no humeral gland; weak supratympanic fold from rear of eye to rear of tympanum, no dorsolateral fold; single, elongate rictal gland continuous with upper lip, extending to axilla; scattered, white spinules on temporal region, tympanic rim, rictal gland, upper and lower lip near gape, and postaxial side of Toe V.

Measurements (mm) of holotype: SVL 65.4; HDL 25.5; HDW 21.0; SNT 10.6; EYE 8.6; IOD 5.0; TMP 5.5; TEY 1.9; SHK 40.3; TGH 37.8; HND 18.3; FTL 34.9.

COLOR OF HOLOTYPE IN LIFE—Dorsum uniform green; side of head to dorsal half of flank dark brown; posterior surface of forearm, ventral half of flank, anterior surface of thigh, posterior surface of thigh, posterior surface of shank, and dorsal surface of foot black with distinct, vermiform, bright yellow markings; upper surfaces of limbs brownish olive with brown cross-bars; upper lip stripe yellow, lower lip black; nuptial pad gray, rictal gland yellow; throat with brownish wash, gular pouch black, belly white; toe webbing purplish brown.

COLOR OF HOLOTYPE IN PRESERVATIVE—Dorsum bluish gray; markings on posterior surface of forearm, ventral half of flank, anterior surface of thigh, posterior surface of thigh, posterior surface of shank, and dorsal surface of foot

creamy-white; upper lip stripe creamy-white; rictal gland creamy-white; toe webbing brown.

VARIATION—Measurements of paratypes summarized in Table 2. SVL of adult males 66–77% SVL of adult females. Ova in preservative approximately 2 mm diameter, uniformly creamy-white, without pigmented hemisphere. Some specimens with Toe IV webbed only to distal subarticular tubercle, with narrow extension to base of disc. Some specimens with divided rictal gland. Females with interorbital distance greater than width of upper eyelid. Females without robust forearm. Females without whitish spinules or with few whitish spinules only on loreal region and tympanic region. Two males without whitish spinules. Females in life with coppery-brown dorsum, three females with small bright green spots on anterior half of dorsum, five females with three to ten round black spots on dorsum.

COMPARISONS—Six other species of *Odorrana* have the combination of first finger longer than the second, all digit tips expanded with circum-marginal grooves, smooth skin on dorsum, light-colored upper lip stripe, males with gular pouches, males without humeral glands, and females with unpigmented eggs: *Odorrana banaorum* (Bain, Lathrop, Murphy, Orlov and Ho, 2003), *O. chloronota* (Günther, 1875), *O. graminea* (Boulenger, 1899), *O. indepressa* (Bain & Stuart, 2005), *O. livida* (Blyth, 1856), and *O. morafkai* (Bain, Lathrop, Murphy, Orlov and Ho, 2003). *Odor-*

rana aureola differs from all of these species by having the posterior surface of forearm, ventral half of flank, anterior surface of thigh, posterior surface of thigh, posterior surface of shank, and dorsal surface of foot black with distinct, vermiform, bright yellow (creamy-white in preservative) markings (absent in the other species). *Odorrana aureola* differs from all of these species except *O. indepressa* by having males with SVL 63.6–67.4 (42.5–54.6 in *banaorum*, 43.3–50.8 in *chloronota*, 44.3–47.0 in *graminea*, 54.3–69.1 in *indepressa*, and 39.2–45.9 in *morafkai*; male *O. livida* are unknown). *Odorrana aureola* further differs from *O. indepressa* by lacking white spinules on the throat, chest, and anterior part of belly (present in *indepressa*).

ETYMOLOGY—The specific epithet *aureola* taken from *aureolus* (L.) for ornamented with gold, in reference to the diagnostic yellow markings on the limbs and flanks of this species.

DISTRIBUTION AND ECOLOGY—*Odorrana aureola* is currently known only from Phu Luang Wildlife Sanctuary and Phu Kradueng National Park (Fig. 1) in Loei Province, Thailand. The Phu Luang specimens were collected at night (1915–2030 h) on boulders, rock outcrops and a fallen tree within 4 m of swift, 1–8-m-wide rocky streams near cascades, except FMNH 265922 was collected in the water at the edge of a 2-m-wide stream with slow current between two small dams. *Odorrana aureola* was collected in sympatry with an apparently undescribed species that morphologically resembles *O. chloronota* (e.g. FMNH 265931/THNHM 05126, FMNH 265932/THNHM 05127) but that is not the sister taxon of *O. chloronota* (Stuart et al., 2006).

REMARKS—*Odorrana aureola* has been historically confused with *Rana livida*, a species now referred to the genus *Odorrana*, but is morphologically (present paper) and genetically (Stuart et al., 2006) distinct from that species. Taylor's (1962) species account of *R. livida* is based on the three male specimens from Phu Kading (=Phu Kradueng National Park) that are included here as paratypes of *O. aureola*: FMNH 172378 = Taylor's field tag 34956, FMNH 172379 = Taylor's field tag 34957, and FMNH 172380 = Taylor's field tag 34958. Taylor noted that these males were larger than males of *R. livida* reported by Boulenger (1920), and suggested that the Phu Kading specimens might be regarded as a separate subspecies of *R. livida*. Taylor's SVL measurements are slightly larger than ours, he made no mention of the white spinules that are

apparent on the temporal region, tympanic rim, and rictal gland in these specimens, and his description of color in life is probably based on freshly preserved material, as the distinctive yellow markings in this species are described as white; otherwise, his description agrees with ours.

Inger and Chan-ard (1997) noted that males of *R. livida* from Khao Yai National Park and Loei Province in the holdings of the Field Museum are significantly larger than other males from mainland Southeast Asia and have spinules under the chin, throat, chest, and upper lip. This series is now known to be a composite of two species, both having large males: those from Khao Yai are the types of *O. indepressa*, and those from Loei Province are Taylor's specimens included here as paratypes of *O. aureola*.

Taylor (1962: 469 as *R. livida*) provided a photograph of paratype male FMNH 172379 in preservative, and Chan-ard (2003: 139 as *Rana* sp.) provided a photograph of a female paratype in life.

Genus *Fejervarya* Bolkey, 1915

Fejervarya triora sp. nov.

Fejervarya sp. Chan-ard, 2003: 110.

HOLOTYPE—FMNH 266172/THNHM 05325 (field tag HKV 66397), deposited at THNHM, adult female (Fig. 8), collected on igneous bedrock away from water in deciduous dipterocarp forest with grassy understory at the headquarters of Phu Jong-Na Yoi National Park, Na Chaloey District, Ubon Ratchatani Province, Thailand, 14°26'05.2"N 105°15'12.8"E, 230 m elevation, on 12 September 2004 by Yodchaiy Chuaynkern, Bryan L. Stuart, Chatchay Chuechat, and Sunchai Makchai.

PARATYPES—FMNH 266160/THNHM 05354, FMNH 266163/THNHM 05357, FMNH 266166/THNHM 05360, FMNH 266169/THNHM 05363, FMNH 266174/THNHM 05367, FMNH 266177/THNHM 05370, FMNH 266178/THNHM 05371, FMNH 266179/THNHM 05372 (eight adult females), same data as holotype. FMNH 266182/THNHM 05375 (one adult female), collected in Phu Jong-Na Yoi National Park, Na Chaloey District, Ubon Ratchatani Province, Thailand, 14°26'18.6"N 105°16'04.5"E, 325 m elevation, on 13 September 2004 by Yodchaiy Chuaynkern, Bryan L. Stuart, Chatchay Chuechat, and Sunchai Makchai. FMNH 266161/THNHM 05355, FMNH 266162/THNHM 05356, FMNH 266164/THNHM 05358, FMNH 266165/THNHM 05359, FMNH 266167/THNHM 05361, FMNH 266168/THNHM 05362, FMNH



FIG. 8. The adult female holotype (FMNH 266172/THNHM 05325) of *Fejervarya trion* sp. nov. in preservative. Clockwise from upper left: palmar view of hand; plantar view of foot; lateral view of head; dorsal view; ventral view.

266170/THNHM 05364, FMNH 266171/THNHM 05365, FMNH 266173/THNHM 05366, FMNH 266175/THNHM 05368, FMNH 266176/THNHM 05369 (11 immature unsexed specimens), same data as holotype. FMNH 266180/THNHM 05373, FMNH 266181/THNHM 05374 (two immature unsexed specimens), collected at Huay Luang Waterfall, Phu Jong-Na Yoi National Park, Na Chaloey District, Ubon Ratchatani Province, Thailand, 14°26'32.8"N 105°16'23.0"E, 350 m elevation, on 13 September 2004 by Yodchaiy Chuaynkern, Bryan L. Stuart, Chatchay Chuechat, and Sunchai Makchai. FMNH 266183/THNHM 05376 (one immature unsexed specimen), collected at Huay Hag Mai Stream, Phu Jong-Na Yoi National Park, Na Chaloey District, Ubon Ratchatani Province, Thailand, 14°25'57.4"N 105°15'24.0"E, 300 m elevation, on 14 September 2004 by Yodchaiy Chuaynkern, Bryan L. Stuart, Chatchay Chuechat, and Sunchai Makchai. FMNH 266184/THNHM 05377, FMNH

266185/THNHM 05378 (two immature unsexed specimens), collected at Huay Luang Noi Stream, Phu Jong-Na Yoi National Park, Na Chaloey District, Ubon Ratchatani Province, Thailand, 14°26'15.9"N 105°16'48.2"E, 360 m elevation, on 15 September 2004 by Yodchaiy Chuaynkern, Bryan L. Stuart, Chatchay Chuechat, and Sunchai Makchai (Fig. 9).

OTHER MATERIAL—FMNH 266337/THNHM 05392, tadpoles (Figs. 10–11), collected at type locality on 13 September 2004 by Yodchaiy Chuaynkern, Bryan L. Stuart, Chatchay Chuechat, and Sunchai Makchai.

DIAGNOSIS—A species of *Fejervarya* having females with SVL 54.9–60.2; head width greater than head length; broad supratympanic fold obscuring dorsoposterior margin of tympanum; skin on dorsum and flank granular with large oval warts, some elongate warts on back at level slightly posterior to insertion of forearm with



FIG. 9. An adult female paratype of *Fejervarya triora* sp. nov. in life.

body; Finger II shorter than Finger IV; outer metatarsal tubercle present; pineal body visible; and lower half of tympanum yellow or orange in life.

DESCRIPTION OF HOLOTYPE—Habitus robust; head broad, wider than long; snout obtusely pointed in dorsal view, projecting beyond lower jaw, round in profile; nostril dorsolateral, closer to tip of snout than eye; canthus rounded, slightly constricted behind nostrils; lores concave and oblique; eye diameter 70% snout length; interorbital distance less than width of upper eyelid; pineal body visible; distinct tympanum, dorsoposterior margin obscured by supratympanic fold, 65% the eye diameter, not depressed relative to skin of temporal region, tympanic rim weakly elevated relative to tympanum; vomerine teeth on two oblique ridges, equal in distance to each other as to choanae; median protuberance at tip of mandible; tongue notched.

Tips of all four fingers rounded, not expanded into discs; relative finger lengths $II < IV < I < III$; no webbing; movable flap of skin on preaxial side of Fingers II and III; distinct subarticular tubercles, one subarticular tubercle on Fingers I and II, two subarticular tubercles on Fingers III and IV; distinct palmar tubercles, one palmar

tubercle at base of Finger I, two palmar tubercles in contact at base of Fingers II, III, and IV.

Tips of toes rounded, not expanded into discs; Toe III longer than Toe V; Toe I webbed to base of distal phalanx; preaxial side of Toe II webbed to proximal edge of subarticular tubercle, continuing as narrow fringe to base of distal phalanx, postaxial side of Toe II webbed to base of distal phalanx; preaxial side of Toe III webbed to proximal edge of distal subarticular tubercle, continuing as narrow fringe to base of distal phalanx, postaxial side of Toe III webbed to point between distal subarticular tubercle and tip of digit; preaxial side of Toe IV webbed to distal edge of middle subarticular tubercle, continuing as narrow fringe to base of distal phalanx; Toe V webbed to base of distal phalanx; movable flap of skin on postaxial side of Toe V from level of outer metatarsal tubercle to distal subarticular tubercle; weak fold on distal one-third of tarsus; elongate, oval inner metatarsal tubercle; small outer metatarsal tubercle present, round on right foot, oval on left foot.

Skin on top of head shagreen; skin on dorsum and flank granular with large oval warts, not arranged in longitudinal rows, some elongate warts on back at level slightly posterior to insertion of forearm with body; skin on side of head granular with small warts; skin on venter smooth; skin on upper surface of limbs smooth or lightly shagreen, with scattered round warts; skin on anterior and posterior surface of thigh smooth, on ventroposterior surface of thigh granular; broad, glandular supratympanic fold from posterior edge of upper eyelid to shoulder, obscuring dorsoposterior margin of tympanum; weak, glandular, transverse fold posterior to upper eyelids, connecting supratympanic folds; no dorsolateral fold; large rectal gland.



FIG. 10. Lateral view of tadpole (FMNH 266337/THNHM 05392) of *Fejervarya triora* sp. nov. Scale bar = 5 mm.

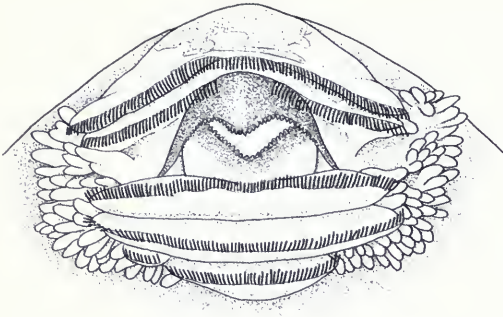


FIG. 11. Mouthparts of tadpole (FMNH 266337/THNHM 05392) of *Fejervarya triora* sp. nov. Scale bar = 1 mm.

Measurements (mm) of holotype: SVL 60.2; HDL 21.2; HDW 24.7; SNT 9.8; EYE 6.9; IOD 3.9; TMP 4.5; TEY 1.5; SHK 30.9; TGH 30.2; HND 12.6; FTL 30.6.

COLOR OF HOLOTYPE IN LIFE—Dorsum olive-brown with green blotches on back and upper surface of limbs; lower half of tympanum with orange blotch; iris bronze; chin and belly grayish white; ventral surface of shank and dorsal surface of foot yellowish with black vermiform markings.

COLOR OF HOLOTYPE IN PRESERVATIVE—Dorsum dark gray with light gray marbling; flank light gray with dark gray marbling; bluish-gray band between outer margin of upper eyelids, followed posteriorly by black inverted triangle; tympanum light orange with dark brown blotch in center; side of head light grayish brown with five broad black vertical bands, the first on side of snout anterior to nostril, third and fourth touching the eye, the fifth below tympanum; upper surface of limbs with dark brown cross-bars; inguinal region and anterior surface of thigh grayish white with dark brown vermiform markings; posterior surface of thigh dark brown with white vermiform markings; lower parts grayish white; underside of hand and foot dark gray; toe webbing brown.

MOLECULAR RESULTS—A tadpole (FMNH 266337/THNHM 05392) and an adult female paratype (FMNH 266160/THNHM 05354) differ in a 694–695 bp fragment of 16S by only the insertion–deletion of a single base pair.

DESCRIPTION OF TADPOLE—Body oval, flattened above, rounded below; tail not as deep as body, fins arising from end of body, maximum depth just anterior to center of tail, tapering gradually to

TABLE 3. Measurements (mm) of *Fejervarya triora* sp. nov. Abbreviations defined in the text.

Measurement	Adult females (holotype and paratypes)
	Range; mean \pm S.D. (N = 10)
SVL	54.9–60.2; 58.1 \pm 1.7
HDL	19.7–21.2; 20.4 \pm 0.4
HDW	22.7–24.7; 23.6 \pm 0.7
SNT	8.6–9.9; 9.1 \pm 0.5
EYE	6.0–6.9; 6.5 \pm 0.3
IOD	2.6–3.9; 3.4 \pm 0.4
TMP	4.4–4.9; 4.6 \pm 0.2
TEY	1.0–1.5; 1.3 \pm 0.2
SHK	29.3–32.3; 30.4 \pm 1.0
TGH	29.1–31.7; 30.0 \pm 0.8
HND	12.0–13.4; 12.6 \pm 0.4
FTL	26.7–30.6; 28.8 \pm 1.2
	Range; median (N = 10)
HDL:HDW	0.80–0.90; 0.87
SNT:HDL	0.42–0.48; 0.45
TMP:EYE	0.65–0.74; 0.72
EYE:SNT	0.67–0.77; 0.71
SHK:SVL	0.50–0.54; 0.52

narrow, rounded tip; tail 1.4–1.6 times body length; tail depth 22–25% of tail length.

Maximum body width 58–64% of body length; body depth 39–50% of body length. Eyes dorsolateral, pointing laterally; nares dorsolateral, between tip of snout and eyes, orientation anterolateral, rim not raised; internarial slightly narrower than interorbital. Spiracle sinistral, much closer to eye than to end of body, midway up side, tube not free of body wall. Anal tube extending slightly beyond margin of ventral fin, opening dextral.

Oral disk ventral, at anterior tip of body; posterior lip with one row of very short papillae, row with wide median gap; papillae of anterior lip confined to corners; labial tooth formula 2(2)/3(1), P1 sometimes with a narrow median break, P3 about half length of other rows; jaw sheaths black in marginal half, finely serrate, anterior jaw sheath with strong median convexity.

Color in preservative of body dark brown above and on sides, without markings, ventrally body without pigment; caudal muscle dark brown, yellowish without melanophores along ventral edge; dorsal fin heavily pigmented, dark brown; ventral fin heavily pigmented only in distal third where it is colored like dorsal fin.

Body lengths (stage = mm): 27 = 9.0, 9.3; 32 = 11.0, 11.3; 37 = 12.4; 38 = 11.5; 40 = 13.2.

VARIATION—Measurements of paratypes summarized in Table 3. Ova in preservative approx-

imately 1.1–1.2 mm diameter, creamy-white with black hemisphere. Adult males are unknown. Dorsum in life olive, brown, olive-brown, reddish brown, or dark gray, with black, brown, green, gold, or orange blotches. Dorsum in preservative variable in amount of dark and light gray coloration, sometimes with black blotches. Tympanic marking in life golden yellow, yellow, or orange. Vermiform markings on posterior surface of thigh in life greenish gold, pale gold, or whitish silver.

COMPARISONS—Three other species of *Fejervarya* are known within the vicinity of eastern Thailand (Thailand, Myanmar, Cambodia, Laos, and Vietnam): *F. cancrivora* (Gravenhorst, 1829), *F. limnocharis* (Gravenhorst, 1829), and *F. raja* (Smith, 1930). *Fejervarya tritora* differs from *F. cancrivora* and *F. limnocharis* by having head width greater than head length (head width less than head length in *cancrivora* and head width less than or equal to head length in *limnocharis*), having a broad supratympanic fold obscuring dorsoposterior margin of tympanum (not obscured in *cancrivora* and *limnocharis*), and lacking elongated ridges on most of dorsum (present in *cancrivora* and *limnocharis*). *Fejervarya tritora* also differs from *F. cancrivora* by having an outer metatarsal tubercle (absent in *cancrivora*) and from *F. limnocharis* by lacking a medial stripe (often present in *limnocharis*). *Fejervarya tritora* differs from *F. raja* by having females with SVL 54.9–60.2 (94.0–107.1 in *raja*) and having an outer metatarsal tubercle (absent in *raja*).

ETYMOLOGY—The specific epithet *tritora* taken from *tri* (L.) for three and *ora* (L.) for border, in reference to the new species' occurrence very close to the triborder area of Thailand, Laos and Cambodia.

DISTRIBUTION AND ECOLOGY—*Fejervarya tritora* is currently known only from Phu Jong-Na Yoi National Park in Ubon Ratchatani Province, Thailand (Fig. 1). The frogs were collected at night (1900–2100 h) in a variety of habitats: on igneous bedrock in deciduous dipterocarp forest with grassy understory, on a road through hilly evergreen forest, and in hilly evergreen forest near flowing, rocky streams. Tadpoles were collected during the day (1400 h) in a rain-filled depression on igneous bedrock in deciduous dipterocarp forest with grassy understory. *Fejervarya tritora* was collected in sympatry with *F. limnocharis* (e.g., FMNH 266070/THNHM 05222, FMNH 266071/THNHM 05223), although the new species was much more frequently encountered than *F. limnocharis*.



FIG. 12. An adult female (FMNH 265991/THNHM 05330) of *Rhacophorus jarujini* Matsui and Panha, 2006. Scale bar = 5 mm.

Family Rhacophoridae

Genus *Rhacophorus* Kuhl and van Hasselt, 1822

Rhacophorus jarujini Matsui and Panha, 2006

MATERIAL EXAMINED—FMNH 265987/THNHM 05326, FMNH 265988/THNHM 05327, FMNH 265989/THNHM 05328, FMNH 265996/THNHM 05324 (four adult males), collected at headquarters of Phu Jong-Na Yoi National Park, Na Chaloe District, Ubon Ratchatani Province, Thailand, 14°26'05.2"N 105°15'12.8"E, 230 m elevation, 12–15 September 2004 by Yodchaiy Chuaynkern, Bryan L. Stuart, Chatchay Chuechat, and Sunchai Makchai. FMNH 265990/THNHM 05329, FMNH 265992/THNHM 05331, FMNH 265993/THNHM 05332, FMNH 265994/THNHM 05333, FMNH 265995/THNHM 05334, FMNH 265997/THNHM 05335, FMNH 265998/THNHM 05336, FMNH 265999/THNHM 05337, FMNH 266000/THNHM 05338 (nine adult males), FMNH 265991/THNHM 05330 (one adult female; Fig. 12), FMNH 266339/THNHM 05396 (tadpoles; Figs. 13–14), collected in Phu Jong-Na Yoi National Park, Na Chaloe District, Ubon Ratchatani Province, Thailand, 14°26'18.6"N 105°16'04.5"E, 325 m elevation, on 13–15 September 2004 by Yodchaiy Chuaynkern, Bryan L. Stuart, Chatchay Chuechat, and Sunchai Makchai. FMNH 266001/THNHM 05339, FMNH 266002/THNHM 05340 (two adult males), collected in Phu Jong-Na Yoi National Park, Na Chaloe District, Ubon Ratchatani Province, Thailand, 14°26'05.4"N 105°15'31.5"E, 270 m elevation, on 15 September 2004 by Yodchaiy Chuaynkern,

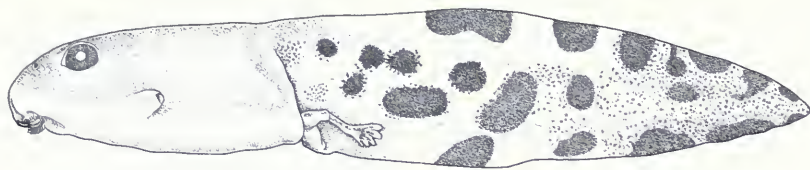


FIG. 13. Lateral view of tadpole (FMNH 266339/THNHM 05396) of *Rhacophorus jarujini* Matsui and Panha, 2006. Scale bar = 5 mm.

Bryan L. Stuart, Chatchay Chuechat, and Sunchai Makchai.

This series of 15 adult males and one adult female fully agrees with Matsui and Panha's (2006) recent description of *Rhacophorus jarujini* from Phu Sri Tan Wildlife Sanctuary in Kalasin Province and Phu Pha Namtip Non-hunting Area in Roi Et Province, eastern Thailand (Fig. 1). However, Matsui and Panha (2006) did not obtain tadpoles of their new species. An individual belonging to the series of strikingly colored tadpoles that we collected at Phu Jong-Na Yoi National Park (FMNH 266339/THNHM 05396) is identical in a 466 bp fragment of ND3 to an adult male (FMNH 265995/THNHM 05334) from the same locality, and we therefore assign these tadpoles to *Rhacophorus jarujini*.

DESCRIPTION OF TADPOLE—Body oval, slightly flattened above and below; tail slightly deeper than body, fins arising from end of body, maximum depth at end of proximal third, tail tapering gradually to rounded tip; tail 1.8–2.0 times body length, tail depth 22–26% of tail length. Maximum body width 50–57% of body length, body depth 43% of body length. Eyes dorsolateral, not visible from below, pointing laterally. Nares dorsolateral, midway between tip of snout and eyes, dorsal rim slightly raised, orientation anterolateral. Spiracle sinistral, closer to eye than to end of body; low on side, tube

not free from body wall. Anal tube short, opening dextral.

Oral disk ventral, at anterior end of body, about two-thirds width of body; posterior lip with continuous single row of short papillae; anterior lip with papillae confined to corners; labial tooth formula 6(3–6)/3, A6 short and often hidden by A5, posterior rows subequal in length; jaw sheaths marginally black, finely serrate, anterior jaw sheath without median convexity.

Color in life of body yellowish gray with gold lateral stripe; anterior one-fourth of tail light yellow, posterior three-fourths bright red, all with irregular black spots.

Color in preservative of body grayish brown above without markings, immaculate white below; tail light straw color, with large brown or black spots on caudal muscle, large black spots along margins of fins.

Body lengths (stage = mm): 28 = 15.0; 36 = 17.3; 38 = 19.0; 41 = 17.3.

DISTRIBUTION AND ECOLOGY—Adults were collected at night (1845–2158 h) in a variety of habitats: on the ground or low vegetation near a rain-filled depression in igneous bedrock in deciduous dipterocarp forest with grassy understory, on the ground next to a seep running over solid rock substrate at the side of a road through deciduous dipterocarp forest, and on vegetation 0.5–1.8 m above a small, rocky stream and a 5- × 7-m pond near a road through hilly evergreen forest. Tadpoles were collected at night (2040–2100 h) in a 1- × 4-m stream pool with silt and leaf litter substrate in hilly evergreen forest. The tadpoles were highly conspicuous with their colorful tails and were well known to park rangers. The call of adult males was *tick tick tick*.

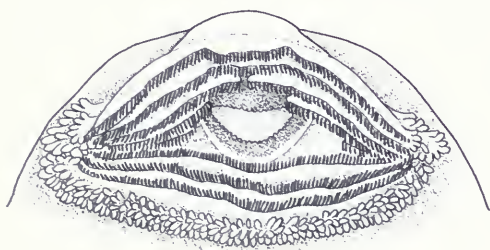


FIG. 14. Mouthparts of tadpole (FMNH 266339/THNHM 05396) of *Rhacophorus jarujini* Matsui and Panha, 2006. Short A6 hidden by A5. Scale bar = 1 mm.

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conducted under the auspices of the Thailand Natural History Museum with permission of the heads of Phu Luang Wildlife Sanctuary, Phu Jong-Na Yoi National Park, and Pang Si Da National Park. Collecting and handling of specimens in the field was in accordance with The Institutional Animal Care and Use Committee of the Field Museum (protocol FMNH 02-3). We are grateful to Jarujin Nabhitabhata for facilitating fieldwork; Chatchay Chuechat and Sunchai Makchai for outstanding assistance in the field; Harold Voris, Alan Resetar, Jamie Ladonski, and Jennifer Mui for facilitating the examination of specimens at the Field Museum; Jens Vindum (California Academy of Sciences), Carla Cicero and Ted Papenfuss (Museum of Vertebrate Zoology), and Robert Murphy and Ross MacCulloch (Royal Ontario Museum) for loaning specimens in their care; Sarah Drasner for photographing preserved specimens; Lisa Kanellos for illustrating the tadpoles; Sean O. Bober for constructing the map; and W. Ronald Heyer, David McLeod, Raoul Bain, André Ngo, Michael Harvey, and Jeff Wilkinson for reviewing the manuscript. Sequencing was conducted in The Field Museum's Pritzker Laboratory for Molecular Systematics and Evolution operated with support from the Pritzker Foundation.

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Appendix I: Material Examined

Megophrys aceras (4)—Trang Province, Thailand: FMNH 216092–216095, males.

Megophrys auralensis (1)—Pursat Province, Cambodia: FMNH 267763, female.

Megophrys brachykolos (2)—Hong Kong, China: FMNH 69063, male holotype; FMNH 109977, female paratype.

Megophrys kuatunensis (2)—Fukien Province, China: FMNH 24408, paratype male; FMNH 24411, paratype female.

Megophrys longipes (1)—Brinchang, Malaysia: FMNH 216240, female.

Megophrys major (26)—Phongsaly Province, Laos: FMNH 258571–258576, males; FMNH 258577, female. Huaphahn Province, Laos: FMNH 255542, male. Bolikhamxay Province, Laos: FMNH 258539–258541, males; FMNH 258543, female. Khammouan Province, Laos: FMNH 256440–256441, males. Xe Kong Province, Laos: FMNH 258544, FMNH 258546–258548, males; FMNH 258545, female. Gia Lai Province, Vietnam: FMNH 252897–252898, females. Nghe An Province, Vietnam: FMNH 255687, 255693, males; FMNH 255692, female. Vinh Phu Province, Vietnam: FMNH 254247, male; FMNH 254248, female.

Megophrys minor (2)—Sichuan Province, China: FMNH 49523, 167973, males.

Megophrys nasuta (6)—Sabah, Malaysia: FMNH 231292, 231325, 231327, males; FMNH 231318, 231328, 231330, females.

Megophrys palpebralespinosa (3)—Phongsaly Province, Laos: FMNH 258098–99, males; FMNH 258100, female.

Megophrys parva (2)—Phongsaly Province, Laos: FMNH 258578, female. Huaphahn Province, Laos: FMNH 255543, male.

Odorrana banaorum (2)—Gia Lai Province, Vietnam: ROM 39913, paratype male; ROM 39901, paratype female.

Odorrana chloronota (16)—Assam, India: FMNH 72416, 74158, males. Shan State, Myanmar: CAS 221771–221772, males. Rakhine State, Myanmar: CAS 220261, male; CAS 216574, 220186–220187, 220260, 222907, females. Kachin State, Myanmar: CAS 221315, female. Bago State, Myanmar: CAS 211719, 211671, females. Pra-

chuap Kirikhan Province, Thailand: FMNH 263416–18, males.

Odorrana graminea (1)—Hainan Province, China: MVZ 230420, male.

Odorrana indepressa (18)—Nakhon Ratchasima Province, Thailand: FMNH 183666, holotype male; FMNH 183653, 183660, 183663–183665, paratype males; FMNH 183649–50, 183652, 183654–183659, 183661–183662, paratype females. Nakhon Nayok Province, Thailand: FMNH 183651, paratype male.

Odorrana livida (1)—Prachuap Kirikhan Province, Thailand: FMNH 263415, female.

Odorrana morafkai (8)—Gia Lai Province, Vietnam: ROM 39907, paratype male; ROM

39947, paratype female. Champasak Province, Laos: FMNH 258238–258240, males; FMNH 258592–258594, females.

Fejervarya cancrivora (1)—Java, Indonesia: FMNH 256688, neotype male.

Fejervarya limnocharis (13)—Java, Indonesia: FMNH 131129, 256721, females. Ubon Ratchatani Province, Thailand: FMNH 266070, male; FMNH 266071, female. Champasak Province, Laos: FMNH 255166, 255184–255185, 258286, males; FMNH 255167, 255183, 258287, 258290, 258292, females.

Fejervarya raja (6)—Phattalung, Thailand: FMNH 175923–175925, females; FMNH 175926, male. Nakhon Si Thammarat, Thailand: FMNH 174052–174053, males.

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